A DIVERSITY RECEIVING SYSTEM FOR REPEATERS

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"Baz" Barrett started with amateur radio at an early age, encouraged by his father, G2BWW. He joined the RSGB at the age of 12 and was licensed in 1969 while still at school. He has been on the committee of the Reading & District Amateur Radio Club since 1972, and was a founder member of the Berkshire Downs Repeater Group. He built GB3BK, GB3RD and GB3RU. By profession he is a radio systems engineer and currently a director of Key Radio Systems Ltd.

THE BERKSHIRE DOWNS REPEATER GROUP was formed in 1977 by members of the Reading and District Amateur Radio Club. The original repeater was GB3BK on 432MHz and this was later joined by GB3RD on 144MHz and GB3RU on 1·3GHz. After nearly 10 years of service, it was decided to replace the original 432MHz equipment with a Mk2 unit, and incorporate some new ideas. One of these was the implementation of a diversity receiving system, the outlines of which were presented in a lecture at the 1985 RSGB National VHF Convention.

To explain briefly the reason for this experiment, the repeaters are sited on the eastern edge of the Berkshire downs, some nine miles to the west of Reading and looking along the Thames Valley. Although the mobile coverage in the town of Reading was quite good, the signals from portables —with their lower transmit power—were not so reliable. In order to improve matters, some experiments were carried out in 1984-5, replacing the colinear receiving antenna of the repeater with a beam directed towards the town.

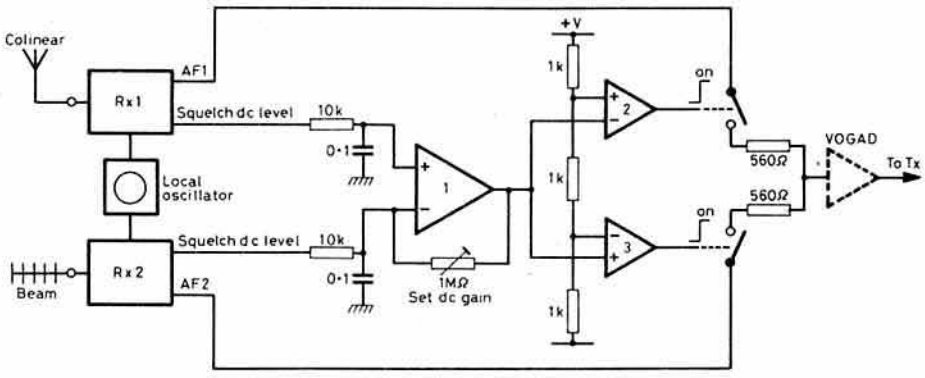

Fig 1. System circuit diagram

As expected, the signals into the beam were greatly improved, but out of it they were reduced, and the idea of using both the colinear and the beam, selecting the source of the strongest signal, and repeating that, was conceived. After a great deal of experimentation, when time permitted, the solution described here was finalized, and has been operating satisfactorily for over a year.

The repeater has two separate, identical receivers, with a common local oscillator. One takes signals from the colinear, and the other from the beam. If the two receivers have equally, strong signals from the same source, the two demodulated outputs are coherent and identical, enabling them to be summed at audio without distortion. As the equal signal is reduced in level to the point where it becomes noisy, there is an interesting effect. Because the two noise components are random and the wanted audio is coherent, the summed signal has a better signal-to-noise ratio than either of the individual signals. This is most useful at the weaker levels, so it was decided to exploit this factor in the design, rather than simply switching between the two signals.

Subjective tests with speech, showed that the optimum improvement by summing was when the two signals differed in sinad (signal to noise and distortion) or quieting, by less than 6dB. For greater differentials, the noisier signal tended to degrade the quieter one. The final version used a mixture of summing and switching. There is a "sinad window", and if the two signals fall within it they are summed and, if they fall outside, the weaker one is switched out.

One other problem had to be overcome, the summed signal is in theory twice the amplitude of each individual one. This is mostly overcome by summing the two low-impedance audio outputs through a resistive combiner, and switching the inputs to it. This reduces the combined level by 6dB, but barely attenuates at all when one leg is open circuit. Just to make sure, the output to the transmitter is passed through an age amplifier (vogad) to ensure a constant level of deviation. The vogad cuts in somewhat below the required level, with the useful side-effect that late night "I can't speak any louder because the harmonics are asleep" type of QSOs come out fully deviated. There is, of course, an increase in background noise under these circumstances on all but the strongest signals, which tends to weed out those who use the repeater to compensate for poorly-adjusted transmitters.

Circuit implementation is quite straightforward. The analogue dc output from the squelch circuits of both receivers is tapped off and brought out to the diversity unit. Most fm receivers have a squelch which operates by feeding high-frequency noise from the discriminator into a rectifier, the output of which is at a maximum with no signal input (all noise) and falls to zero with a strong signal (fully quietening). The squelch threshold is set by switching on the audio when this rectified level falls below a pre-determined value. Since many receivers alter the gain of a high-frequency amplifier to set the squelch, it is imprtant that the two receivers are adjusted to be the same.

The two outputs are then fed into a comparator, through simple RC lowpass filters. The dc gain of the comparator is set to a convenient value to give good resolution of the "sinad window". I set it arbitrarily to give one third of supply output at 6dB difference in one direction, and two thirds for 6dB in the other direction. The output of the first comparator is then fed to two more comparators, which set the switching limits of the "window". No hysteresis was found to be needed on the last two comparators as, in real life, signals never remain near either threshold for long. I used a single TL084 quad op-amp for all these, although the type is not critical. The outputs from these two comparators are used to control the switches which feed the audio from the receivers to the resistive combiner. I used the HEF4066 hex solidstate switch, but reed relays would be just as good. Care needs to be taken to ensure that there is no dc offset across the switching device, as this will produce a "click" when the voting changes. Finally, the combined output goes through the vogad, which is really a nicety that the system works perfectly well without, provided that the input impedance of the modulator is high, compared with the combiner.

In operation, the system works without vices. The only unusual effect is that occasionally on signals from fixed stations on the side of the beam, the audio changes from faintly noisy to fully quietening and back, as fading makes the switch operate.

The colinear and beam antenna at GB3BK are vertically separated by about three wavelengths, which produces a degree of space as well as directional diversity. This has the added benefit of removing, or reducing deep "nulls" in signals from mobiles moving in slow traffic.

The diversity concept has been described mainly in terms of repeater operation, but it applies equally to any other type of receiving installation. While working on the system at home, I was impressed with the improvement in signals from mobiles when each receiver was connected to one half of a crossed Yagi, so perhaps there is also an application there. □

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